Evaluation of different heuristic functions for Isolation[1] game

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[1] https://en.wikipedia.org/wiki/Isola_(board_game)

Variables used

own_moves	Number of moves available to active player
opponent_moves	Number of moves available to opponent player
board_size	Size of the board (7x7 = 49)
cells_left	Board_size - number of moves made

Description of heuristic functions

Heuristic 1 - (**H1**)

Code:

```
return float(own_moves - 3.5 *  opponent_moves)
```

Description:

Aggressive play along the whole game. Active player will try to choose the most aggressive move. Heuristic calculates number of players move vs agains 3.5 of value of an opponent's moves.

Heuristic 2 - (**H2**)

Code:

```
if cells_left  < int((board_size)/2):
    return float(own_moves - 3 * opponent_moves)
return float(own_moves - 2 * opponent_moves)
```

Description:

Aggressive play after the half of the game. Active player will try to choose the most aggressive move. Heuristic calculates number of players move vs 3.5 of value of an opponent's moves. In the first half of the game heuristic will calculate number of players move vs 2 of value of an opponent's moves.

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Heuristic 3 - (H3)

Code:

```
if cells_left  < int((board_size)/2):
    return float(own_moves - opponent_moves)
return float(own_moves - 3 * opponent_moves)
```

Description:

Aggressive play in the first half of the game. Active player will try to choose the most aggressive move. Heuristic calculates number of players move vs 3.5 of value of an opponent's moves. In the second half of the game heuristic will calculate number of players move vs number of an opponent's moves.

Heuristic 4 - (**H4**)

Code:

```
if cells_left < int((board_size) / 0.4):
    return float(own_moves - opponent_moves)
if cells_left < int((board_size) / 3):
    return float(own_moves - 2 * opponent_moves)
return float(own_moves - 3 * opponent_moves)
```

Description:

Different level of aggressiveness on three different levels of game.

Heuristic 5 - (**H5**)

```
if cells_left < int((board_size) / 0.4):
    return float(own_moves - 3 * opponent_moves)
if cells_left < int((board_size) / 3):
    return float(own_moves - 2 * opponent_moves)
return float(own_moves - opponent_moves)
```

Description:

Similar to H5 but player instead plays less aggressive to the end of the game. (reversed order of aggressiveness)

Heuristic 6 - (**H6**)

Code:

```
if cells_left  < int((board_size)/2):
    return float(own_moves - opponent_moves)
return float(own_moves - 2 * opponent_moves)
```

Description:

Similar to H3 but player instead plays less aggressive at the beginning of the game.
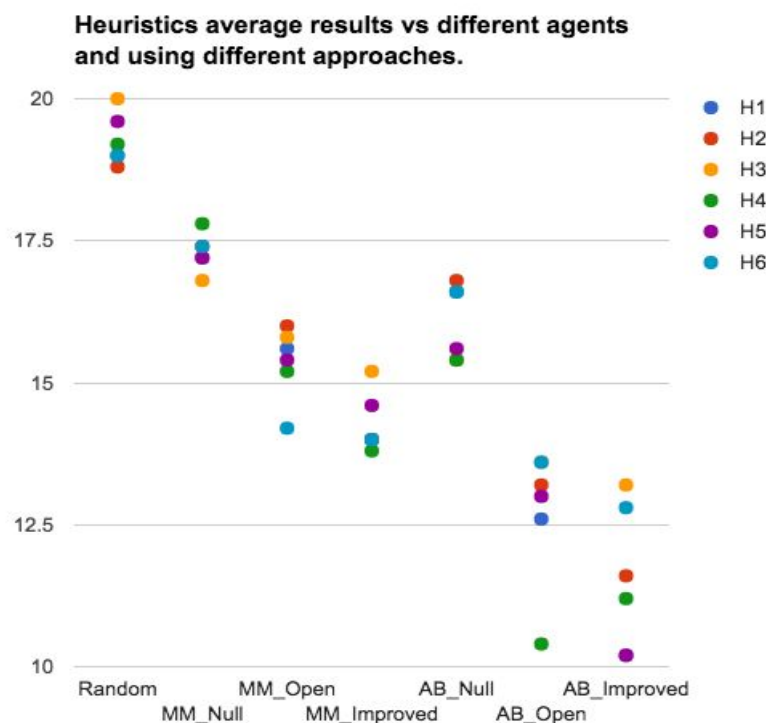
Comparison

The best way to compare all of those heuristic is to make them play against other playing agents multiple times and see the average winning results.

Evaluation results for all of the tournaments for every function are located at the end of the paper in the section **Extended Data Tables**, and alternatively could be access from the link below:
https://docs.google.com/spreadsheets/d/1Vd58r5PFJr_BX_VUpkbXZWjlT3w2jk-RbesI66eVJ-Q/edit?usp=sharing

Results

Graph below contains the average winning results of every heuristic function against other players. Attentions is drawn by the orange heuristic who is leading winner in many cases. It might be not easily seen however next graph will make it more clear.

At this graph that shows us the percentage of wins among the heuristics we can clearly see that heuristic #3 which was orange on previous graph has the highest winning rate.
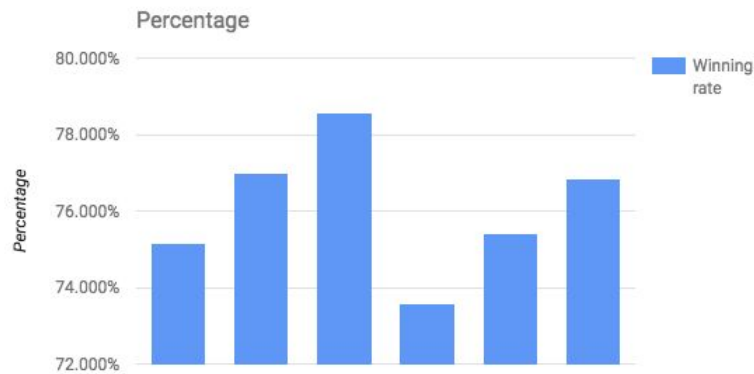
From the analysis and comparison of the results of different heuristic functions we can clearly make clarification the heuristics number 3 is the leader and can be picked as strongest opponent among the other heuristics.

Aggressive play in the first half of the game allows player to select the move which will lead to better outcome at the end of the game. And when that move is selected closer to the end of the game, particularly after the half of the board is blocked it is good choice to switch tactic less aggressive one and just calculate own moves against the moves of the opponent.

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Extended Data Tables

I_1, i_2 … - refer to iteration #1, iteration #2 etc.

Heuristic 1 - (H1)

	i_1	i_2	i_3	i_4	i_5	AVG
Random	20	17	19	19	20	19
MM_Null	15	19	17	18	17	17.2
MM_Open	17	13	17	17	14	15.6
MM_Improved	18	14	12	13	13	14
AB_Null	15	18	13	18	19	16.6
AB_Open	13	13	14	13	10	12.6
AB_Improved	9	10	10	10	12	10.2
Winning Rate	76.43%	74.29%	72.86%	77.14%	75.00%	75%

Heuristic 2 - (H2)

H2	i_1	i_2	i_3	i_4	i_5	AVG
Random	19	19	18	19	19	18.8
MM_Null	18	19	17	17	16	17.4
MM_Open	13	16	18	17	16	16
MM_Improved	15	16	15	12	12	14
AB_Null	17	16	16	18	17	16.8
AB_Open	12	15	12	14	13	13.2
AB_Improved	12	10	12	11	13	11.6
Winning Rate	75.71%	79.29%	77.14%	77.14%	75.71%	77%

Heuristic 3 - (H3)

H3	i_1	i_2	i_3	i_4	i_5	AVG
Random	20	20	20	20	20	20
MM_Null	19	15	18	15	17	16.8
MM_Open	15	16	17	17	14	15.8
MM_Improved	15	15	16	15	15	15.2
AB_Null	16	16	16	13	16	15.4
AB_Open	16	16	12	10	14	13.6
AB_Improved	11	15	14	15	11	13.2
Winning Rate	80.00%	80.71%	80.71%	75.00%	76.43%	79%

Heuristic 4 - (H4)

H4	i_1	i_2	i_3	i_4	i_5	AVG
Random	19	20	18	20	19	**19.2**
MM_Null	16	18	18	19	18	**17.8**
MM_Open	18	13	15	14	16	**15.2**
MM_Improved	13	14	12	15	15	**13.8**
AB_Null	20	17	14	13	13	**15.4**
AB_Open	10	10	12	10	10	**10.4**
AB_Improved	14	12	11	8	11	**11.2**
Winning Rate	**78.57%**	**74.29%**	**71.43%**	**70.71%**	**72.86%**	**74%**

Heuristic 5 - (H5)

H5	i_1	i_2	i_3	i_4	i_5	AVG
Random	20	20	19	20	19	**19.6**
MM_Null	18	16	19	18	15	**17.2**
MM_Open	12	17	19	15	14	**15.4**
MM_Improved	13	16	15	14	15	**14.6**
AB_Null	16	16	15	13	18	**15.6**
AB_Open	14	13	9	18	11	**13**
AB_Improved	12	8	10	10	11	**10.2**
Winning Rate	**75.00%**	**75.71%**	**75.71%**	**77.14%**	**73.57%**	**75%**

Heuristic 6 - (H6)

H6	i_1	i_2	i_3	i_4	i_5	AVG
Random	20	18	19	20	18	**19**
MM_Null	17	18	18	17	17	**17.4**
MM_Open	13	14	13	18	13	**14.2**
MM_Improved	15	16	14	12	13	**14**
AB_Null	14	16	17	18	18	**16.6**
AB_Open	14	14	13	14	13	**13.6**
AB_Improved	13	12	13	11	15	**12.8**
Winning Rate	**75.71%**	**77.14%**	**76.43%**	**78.57%**	**76.43%**	**77%**

Combined table of all average heuristics scores

	H1	H2	H3	H4	H5	H6
Random	19	18.8	20	19.2	19.6	19
MM_Null	17.2	17.4	16.8	17.8	17.2	17.4
MM_Open	15.6	16	15.8	15.2	15.4	14.2
MM_Improved	14	14	15.2	13.8	14.6	14
AB_Null	16.6	16.8	15.4	15.4	15.6	16.6
AB_Open	12.6	13.2	13.6	10.4	13	13.6
AB_Improved	10.2	11.6	13.2	11.2	10.2	12.8
Winning rate	**75.143%**	**77.000%**	**78.571%**	**73.571%**	**75.429%**	**76.857%**